

MULTIMEDIA



UNIVERSITY

STUDENT ID NO

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MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 2, 2019/2020

BSA1024 – STATISTICS
(All sections / Groups)

02 MARCH 2020
9.00a.m - 11.00a.m
(2 Hours)

INSTRUCTIONS TO STUDENTS

1. This question paper consists of **THIRTEEN (13)** printed pages with:
Section A: Ten (10) multiple choice questions (20%)
Section B: Three (3) structured questions (80%)
2. Answer **all** questions.
3. Answer **Section A** in the multiple-choice answer sheet provided and **Section B** in the answer booklet provided.
4. Formula and Statistical tables are attached at the end of the question paper.
5. Students are allowed to use non-programmable scientific calculators with no restrictions.

SECTION A: MULTIPLE CHOICE QUESTIONS (20 MARKS)

There are TEN (10) questions in this section. Answer ALL questions on the multiple-choice answer sheet.

1. _____ is used to compare the variation or dispersion in two or more sets of data even though they are measured in different units.

A. Range
B. Standard deviation
C. Coefficient of variation
D. Interquartile range

2. The percent of total variation of the dependent variable Y is explained by the set of independent X is measured by:

A. Coefficient of correlation
B. Coefficient of determination
C. Standard error of estimate
D. Variation for dependent variable Y

3. If a parameter is computed from a set of data, which of the following statements is TRUE?

A. The data are obtained from a census.
B. The data are obtained from a random sample.
C. The data is from a sample that is representative of the population.
D. The data must be quantitative.

4. The probability function of a random variable, X is defined as below:

X	-1	-2	0	1	2
$P(X)$	m	$2m$	$3m$	$4m$	$5m$

What is the value of m ?

A. 0.25
B. 0.125
C. 1/15
D. 1

5. In binomial experiment, the successive trials are _____.

A. Dependent
B. Independent
C. Mutually exclusive
D. Fixed

Continued...

6. Which one of the following variables is *not* quantitative?
- A. Age of a person
 - B. Gender of a person
 - C. Number of dreams recalled
 - D. Number of students in BMS1024 class
7. During the grand opening week of a bicycle shop, it has offers a wheel of discount saving. After customers select the items they wish to purchase, they spin the wheel to determine the discount they will receive. The wheel is divided into 12 slices. 6 slices are red and award a 10% discount, 3 slices are white and award a 20% discount, and 2 slices are blue and award a 40% discount. The remaining slice is gold and awards a 100% discount. The probability that a customer gets at least 40% discount is
- A. 0.25
 - B. 0.1667
 - C. 0.0625
 - D. 0.75
8. A major department store chain is interested in estimating the mean amount its credit card customers spent on their first visit to the chain's new store in the mall. Fifteen credit card accounts were randomly sampled and analyzed with the following results: $\bar{x} = RM50.50$ and $s = RM20$. Assuming the distribution of the amount spent on their first visit is normal, what is the shape of the sampling distribution of the sample mean that will be used to create the desired confidence interval for μ ?
- A. approximately normal with a mean of $RM50.50$
 - B. a standard normal distribution
 - C. a t -distribution with 15 degrees of freedom
 - D. a t -distribution with 14 degrees of freedom
9. A computer software developer would like to use the number of downloads (in thousands) for the trial version of his new software to predict the amount of revenue (in thousands of dollars) on selling the full version of his new software. A table is provided as below to display an output from a simple linear regression analysis:

<i>Multiple R</i>	0.8691
<i>R Square</i>	0.7554
<i>Adjusted R Square</i>	0.7467
<i>Standard Error</i>	44.4765
<i>Observations</i>	30

Continued...

Which of the following is the correct interpretation for the coefficient of determination?

- A. 75.54% of the variation in the number of downloads can be explained by the variation in revenue.
- B. 74.67% of the variation in the number of downloads can be explained by the variation in revenue.
- C. 86.91% of the variation in revenue can be explained by the variation in the number of downloads.
- D. 75.54% of the variation in revenue can be explained by the variation in the number of downloads.

10. In 2001, moving companies are required by the government to publish a Carrier Performance Report. In addition, they need to include the number of shipments which claimed RM50 or greater for damage was filed. There were two companies named; *AK-Move* and *Big-Move*, decided to estimate this figure by sampling their records, and they were reported their data in the following table:

<i>Name of company</i>	<i>AK-Move</i>	<i>Big-Move</i>
Total of shipments sampled	900	750
Number of shipments with a damage claimed \geq RM50	162	60

Which of the hypothesis statistical test would be used to analyze this data?

- A. *t-test* for the difference between two means.
- B. *F-test* for the ratio of variances.
- C. *Z-test* for the difference between two proportions.
- D. Separate variance binomial test for the difference between two means.

Continued...

SECTION B: STRUCTURED QUESTIONS (80) MARKS)

There are **THREE (3)** questions in this section. Candidates **MUST** answer **ALL THREE** questions.

Question 1 (30 Marks)

- a) Isabel is going to play one badminton match and one tennis match. The badminton match has been scheduled one week earlier than tennis match. Based on the prediction by her coach, the chance that she will win the badminton match is $\frac{9}{10}$. Other than that, the coach believed that if Isabel wins the badminton match, the chance that she will win the tennis match is $\frac{3}{5}$. But if she loses the badminton match, she has $\frac{2}{3}$ chance of losing the tennis match too.
- (i) Draw a tree diagram and the probabilities for each events involved for the above scenario. **[8 marks]**
 - (ii) Find the probability that Isabel will win for the tennis match. **[4 marks]**
 - (iii) The matches have been re-scheduled. Given that Isabel won the tennis match, what is the probability that she will also win the badminton match? **[3 marks]**
- b) According to the 2018 population survey conducted by Statistics Department of Malaysia, 32% of the Malaysia population with age 25 years old or over has completed a bachelor' degree or more. Given a random sample of 10 people with age 25 years old or over,
- (i) What is the probability that at most 2 of the selected people has completed a bachelors degree or more? **[4 marks]**
 - (ii) What is the average number of people who have completed a bachelors degree or more from the sample? **[2 marks]**
- c) A test has been devised to measure student's level of motivation during high school. The higher the score the greater the motivation to do well at school. The motivation scores on the test are approximately normally distributed with a mean of 25 and a standard deviation of 6.

Continued...

- (i) What is the probability that a student taking this test will obtain scores between 20 to 28?

[5 marks]

- (ii) Eliya has been told that 35% of the students taking the test have higher motivation scores than she does. What is Eliya's score?

[4 marks]

Question 2 (20 Marks)

- a) In Europe countries, the demand on purchasing homes located only a few steps away from beach is increasing among rich people there. Based on a realtor's claim, the oceanfront homes (directly on the beach) have greater value than oceanside homes, which are not directly on the beach. Listed below are fair market values (in thousands of dollars) of randomly 10 selected homes on Long Beach Island in New Jersey.

<i>Oceanfront</i>	2199	3750	1725	2398	2799	4521	1865	2553	3025	1755
<i>Oceanside</i>	700	1355	795	1575	759	1865	2045	956	825	1348

At 5 percent significance level, can we conclude that oceanfront homes have greater market value compared to oceanside homes?

[10 marks]

- b) The health insurance premium is much higher if an insurer is a smoker. It is due to smokers are more likely to claim insurance due to suffering an early death or a critical illness. An insurance company believed that the male adult is more likely to be a smoker than female adult. From a telephone poll, the result was recorded as below:

	<i>Male Adult</i>	<i>Female Adult</i>
<i>Number of respondent</i>	605	195
<i>Number of smoker</i>	351	41

At the 5 percent significance level, is there enough evidence to support the company's belief?

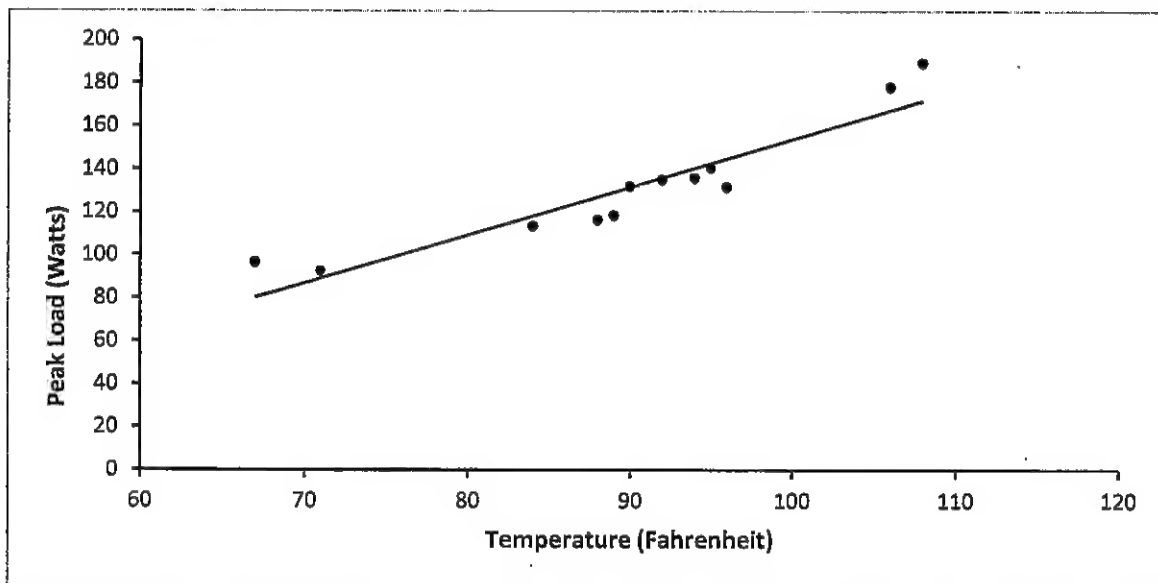
[10 marks]

Question 3 (30 Marks)

- a) Peak power load is the maximum amount of power which need to be generate daily to meet customer's demand. A power company wants to use daily high temperature to predict daily peak power load during the summer season when demand is greatest. These data, scatterplot and summary output of the relationship between the two variables are shown below:

Continued...

<i>Temperature (Fahrenheit)</i>	<i>Peak Load (Watts)</i>
94	136
96	131.7
95	140.7
108	189.3
67	96.5
88	116.4
89	118.5
84	113.4
90	132
106	178.2
71	92.5
92	135.1



Summary Output

<i>Regression Statistics</i>	
Multiple R	0.9342
R Square	0.8728
Adjusted R Square	0.8600
Standard Error	10.7661
Observations	12

Continued...

ANOVA

	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>	<i>Significance F</i>
Regression	1	7950.967864	7950.968	68.59715	8.67897E-06
Residual	10	1159.081302	115.9081		
Total	11	9110.049167			

	<i>Coefficients</i>	<i>Standard Error</i>	<i>t Stat</i>	<i>P-value</i>
Intercept	-69.4402	24.4825	-2.83632	0.017659
Temperature	2.2348	0.2698	8.28234	8.68E-06

- (i) State the dependent variable and the independent variable for the above regression model. [2 marks]
- (ii) Write the least square regression line for the above relationship between the two variables. State the unit of measurement for each variable. [4 marks]
- (iii) What do the coefficient of the regression line tell you about the relationship between peak power load and the temperature during summer? [3 marks]
- (iv) Determine the coefficient of correlation and discuss the role of this coefficient value for this model. [3 marks]
- (v) Predict the peak power load if the temperature is set at 110 Fahrenheit. Is this estimation reliable? Explain. [4 marks]
- (vi) State the coefficient of determination and describe what it tells you. [4 marks]

- b) A table below is consisting selected consumer goods for 2009 and 2019:

Product	2009		2019	
	Price (RM)	Quantity	Price (RM)	Quantity
Food	340	115	345	90
Rent	600	16	600	13
Drinks	120	90	150	120
Transportation	250	43	260	56

Compute and interpret the Laspeyres Price Index (LPI) and Paasche Price Index (PPI) for 2019 using 2009 as the base period.

[10 marks]

End of Page.

STATISTICAL FORMULAE**A. DESCRIPTIVE STATISTICS**

$$\text{Mean } (\bar{x}) = \frac{\sum_{i=1}^n X_i}{n}$$

$$\text{Standard Deviation } (s) = \sqrt{\frac{\sum_{i=1}^n X_i^2}{n-1} - \frac{(\sum_{i=1}^n X_i)^2}{n(n-1)}}$$

$$\text{Coefficient of Variation } (CV) = \frac{\sigma}{\bar{x}} \times 100$$

$$\text{Pearson's Coefficient of Skewness } (S_k) = \frac{3(\bar{X} - \text{Median})}{s}$$

B. PROBABILITY

$$P(A \text{ or } B) = P(A) + P(B) - P(A \text{ and } B)$$

$$P(A \text{ and } B) = P(A) \times P(B) \quad \text{if } A \text{ and } B \text{ are independent}$$

$$P(A | B) = P(A \text{ and } B) \div P(B)$$

Poisson Probability Distribution

$$\text{If } X \text{ follows a Poisson Distribution, } P(\lambda) \text{ where } P(X=x) = \frac{e^{-\lambda} \lambda^x}{x!}$$

$$\text{then the mean} = E(X) = \lambda \text{ and variance} = \text{VAR}(X) = \lambda$$

Binomial Probability Distribution

$$\text{If } X \text{ follows a Binomial Distribution } B(n, p) \text{ where } P(X=x) = {}^n C_x p^x q^{n-x}$$

$$\text{then the mean} = E(X) = np \text{ and variance} = \text{VAR}(X) = npq \text{ where } q = 1-p$$

Normal Distribution

$$\text{If } X \text{ follows a Normal distribution, } N(\mu, \sigma) \text{ where } E(X) = \mu \text{ and } \text{VAR}(X) = \sigma^2$$

$$\text{then } Z = \frac{X - \mu}{\sigma}$$

C. EXPECTATION AND VARIANCE OPERATORS

$$E(X) = \sum [X \cdot P(X)]$$

$$\text{VAR}(X) = E(X^2) - [E(X)]^2 \quad \text{where } E(X^2) = \sum [X^2 \cdot P(X)]$$

$$\text{If } E(X) = \mu \text{ then } E(cX) = c\mu, \quad E(X_1 + X_2) = E(X_1) + E(X_2)$$

$$\text{If } \text{VAR}(X) = \sigma^2 \text{ then } \text{VAR}(cX) = c^2 \sigma^2,$$

$$\text{VAR}(X_1 + X_2) = \text{VAR}(X_1) + \text{VAR}(X_2) + 2 \text{COV}(X_1, X_2)$$

$$\text{where } \text{COV}(X_1, X_2) = E(X_1 X_2) - [E(X_1) E(X_2)]$$

D. CONFIDENCE INTERVAL ESTIMATION AND SAMPLE SIZE DETERMINATION

(100 – α) % Confidence Interval for Population Mean (σ Known) =

$$\mu = \bar{X} \pm Z_{\alpha/2} \left(\frac{\sigma}{\sqrt{n}} \right)$$

(100 – α)% Confidence Interval for Population Mean (σ Unknown) =

$$\mu = \bar{X} \pm t_{\alpha/2, n-1} \left(\frac{s}{\sqrt{n}} \right)$$

(100 – α)% Confidence Interval for Population Proportion = $\hat{p} \pm Z_{\alpha/2} \sigma_{\hat{p}}$

Where $\sigma_{\hat{p}} = \sqrt{\frac{\hat{p}(1-\hat{p})}{n}}$

Sample Size Determination for Population Mean = $n \geq \left[\frac{(Z_{\alpha/2})\sigma}{E} \right]^2$

Sample Size Determination for Population Proportion = $n \geq \frac{(Z_{\alpha/2})^2 \hat{p}(1-\hat{p})}{E^2}$

Where E = Limit of Error in Estimation

E. HYPOTHESIS TESTING

One Sample Mean Test	
Standard Deviation (σ) Known	Standard Deviation (σ) Not Known
$Z = \frac{\bar{x} - \mu}{\sigma / \sqrt{n}}$	$t = \frac{\bar{x} - \mu}{s / \sqrt{n}}$
One Sample Proportion Test	
$Z = \frac{\hat{p} - p}{\sigma_p} \quad \text{where } \sigma_p = \sqrt{\frac{p(1-p)}{n}}$	
Two Sample Mean Test	
Standard Deviation (σ) Known	Standard Deviation (σ) Not Known
$Z = \frac{(\bar{x}_1 - \bar{x}_2) - (\mu_1 - \mu_2)}{\sqrt{\sigma_1^2/n_1 + \sigma_2^2/n_2}}$	$t = \frac{(\bar{x}_1 - \bar{x}_2) - (\mu_1 - \mu_2)}{\sqrt{S_p^2 \left(\frac{1}{n_1} + \frac{1}{n_2} \right)}}$ <p>where $S_p^2 = \frac{(n_1 - 1)S_1^2 + (n_2 - 1)S_2^2}{(n_1 + n_2 - 2)}$</p>
Two Sample Proportion Test	
$Z = \frac{\hat{p}_1 - \hat{p}_2}{\sqrt{p(1-p) \left(\frac{1}{n_1} + \frac{1}{n_2} \right)}} \quad \text{where } p = \frac{X_1 + X_2}{n_1 + n_2}$ <p>where X_1 and X_2 are the number of successes from each population</p>	

F. REGRESSION ANALYSIS**Simple Linear Regression****Population Model:** $Y = \beta_0 + \beta_1 X_1 + \varepsilon$ **Sample Model:** $\hat{y} = b_0 + b_1 x_1 + e$ **Correlation Coefficient**

$$r = \frac{\sum XY - \left[\frac{\sum X \sum Y}{n} \right]}{\sqrt{\left[\sum X^2 - \left(\frac{(\sum X)^2}{n} \right) \right] \left[\sum Y^2 - \left(\frac{(\sum Y)^2}{n} \right) \right]}} = \frac{COV(X,Y)}{\sigma_x \sigma_y}$$

ANOVA Table for Regression

Source	Degrees of Freedom	Sum of Squares	Mean Squares
Regression	1	SSR	MSR = SSR/1
Error/Residual	$n - 2$	SSE	MSE = SSE/($n - 2$)
Total	$n - 1$	SST	

Test Statistic for Significance of the Predictor Variable

$$t_i = \frac{b_i}{S_{b_i}} \text{ and the critical value} = \pm t_{\alpha/2, (n-p-1)}$$

*Where p = number of predictor***G. INDEX NUMBERS**

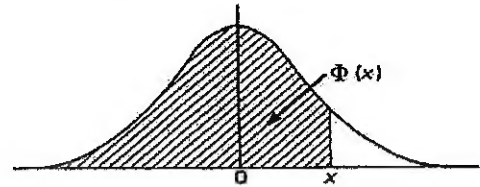
Simple Price Index $P = \frac{p_t}{p_0} \times 100$	Laspeyres Quantity Index $P = \frac{\sum p_0 q_t}{\sum p_0 q_0} \times 100$
Aggregate Price Index $P = \frac{\sum p_t}{\sum p_0} (100)$	Paasche Quantity Index $P = \frac{\sum p_t q_t}{\sum p_t q_0} \times 100$
Laspeyres Price Index $P = \frac{\sum p_t q_0}{\sum p_0 q_0} \times 100$	Fisher's Ideal Price Index $\sqrt{(\text{Laspeyres Price Index})(\text{Paasche Price Index})}$
Paasche Price Index $P = \frac{\sum p_t q_t}{\sum p_0 q_t} \times 100$	Value Index $V = \frac{\sum p_t q_t}{\sum p_0 q_0} \times 100$

STATISTICAL TABLE

TABLE 4. THE NORMAL DISTRIBUTION FUNCTION

The function tabulated is $\Phi(x) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^x e^{-t^2/2} dt$. $\Phi(x)$ is

the probability that a random variable, normally distributed with zero mean and unit variance, will be less than or equal to x . When $x < 0$ use $\Phi(x) = 1 - \Phi(-x)$, as the normal distribution with zero mean and unit variance is symmetric about zero.



x	$\Phi(x)$	x	$\Phi(x)$	x	$\Phi(x)$	x	$\Phi(x)$	x	$\Phi(x)$	x	$\Phi(x)$
0.00	0.5000	0.40	0.6554	0.80	0.7881	1.20	0.8849	1.60	0.9452	2.00	0.97725
0.01	5040	41	6591	81	7910	21	8869	61	9463	01	97778
0.02	5080	42	6628	82	7939	22	8888	62	9474	02	97831
0.03	5120	43	6664	83	7967	23	8907	63	9484	03	97882
0.04	5160	44	6700	84	7995	24	8925	64	9495	04	97932
0.05	5199	45	6736	85	8023	25	8944	65	9505	05	97982
0.06	5239	46	6772	86	8051	26	8962	66	9515	06	98030
0.07	5279	47	6808	87	8078	27	8980	67	9525	07	98077
0.08	5319	48	6844	88	8106	28	8997	68	9535	08	98124
0.09	5359	49	6879	89	8133	29	9015	69	9545	09	98169
0.10	5398	50	6915	90	8159	30	9032	70	9554	10	98214
11	5438	51	6950	91	8186	31	9049	71	9564	11	98257
12	5478	52	6985	92	8212	32	9066	72	9573	12	98300
13	5517	53	7019	93	8238	33	9082	73	9582	13	98341
14	5557	54	7054	94	8264	34	9099	74	9591	14	98382
0.15	5596	55	7088	95	8289	35	9115	75	9599	15	98422
16	5636	56	7123	96	8315	36	9131	76	9608	16	98461
17	5675	57	7157	97	8340	37	9147	77	9616	17	98500
18	5714	58	7190	98	8365	38	9162	78	9625	18	98537
19	5753	59	7224	99	8389	39	9177	79	9633	19	98574
0.20	5793	60	7257	1.00	8413	40	9192	80	9641	20	98610
21	5832	61	7291	01	8438	41	9207	81	9649	21	98645
22	5871	62	7324	02	8461	42	9222	82	9656	22	98679
23	5910	63	7357	03	8485	43	9236	83	9664	23	98713
24	5948	64	7389	04	8508	44	9251	84	9671	24	98745
0.25	5987	65	7422	05	8531	45	9265	85	9678	25	98778
26	6026	66	7454	06	8554	46	9279	86	9686	26	98809
27	6064	67	7486	07	8577	47	9292	87	9693	27	98840
28	6103	68	7517	08	8599	48	9306	88	9699	28	98870
29	6141	69	7549	09	8621	49	9319	89	9706	29	98899
0.30	6179	70	7580	1.10	8643	50	9332	90	9713	30	98928
31	6217	71	7611	11	8665	51	9345	91	9719	31	98956
32	6255	72	7642	12	8686	52	9357	92	9726	32	98983
33	6293	73	7673	13	8708	53	9370	93	9732	33	99010
34	6331	74	7704	14	8729	54	9382	94	9738	34	99036
0.35	6368	75	7734	1.15	8749	55	9394	95	9744	35	99061
36	6406	76	7764	16	8770	56	9406	96	9750	36	99086
37	6443	77	7794	17	8790	57	9418	97	9756	37	99111
38	6480	78	7823	18	8810	58	9429	98	9761	38	99134
39	6517	79	7852	19	8830	59	9441	99	9767	39	99158
0.40	6554	80	7881	2.00	8849	60	9452	2.00	9772	2.40	99180

TABLE 4. THE NORMAL DISTRIBUTION FUNCTION

z	$\Phi(z)$	z	$\Phi(z)$	z	$\Phi(z)$	z	$\Phi(z)$	z	$\Phi(z)$	z	$\Phi(z)$
2.40	0.99180	2.55	0.99461	2.70	0.99653	2.85	0.99781	3.00	0.99865	3.15	0.99918
41	99202	56	99477	71	99664	86	99788	01	99869	16	99921
42	99224	57	99492	72	99674	87	99795	02	99874	17	99924
43	99245	58	99506	73	99683	88	99801	03	99878	18	99926
44	99266	59	99520	74	99693	89	99807	04	99882	19	99929
2.45	0.99286	2.60	0.99534	2.75	0.99702	2.90	0.99813	3.05	0.99886	3.20	0.99931
46	99305	61	99547	76	99711	91	99819	06	99889	21	99934
47	99324	62	99560	77	99720	92	99825	07	99893	22	99936
48	99343	63	99573	78	99728	93	99831	08	99896	23	99938
49	99361	64	99585	79	99736	94	99836	09	99900	24	99940
2.50	0.99379	2.65	0.99598	2.80	0.99744	2.95	0.99841	3.10	0.99903	3.25	0.99942
51	99396	66	99609	81	99752	96	99846	11	99906	26	99944
52	99413	67	99621	82	99760	97	99851	12	99910	27	99946
53	99430	68	99632	83	99767	98	99856	13	99913	28	99948
54	99446	69	99643	84	99774	99	99861	14	99916	29	99950
2.55	0.99461	2.70	0.99653	2.85	0.99781	3.00	0.99865	3.15	0.99918	3.30	0.99952

The critical table below gives on the left the range of values of z for which $\Phi(z)$ takes the value on the right, correct to the last figure given; in critical cases, take the upper of the two values of $\Phi(z)$ indicated.

3.075	0.9990	3.263	0.9994	3.731	0.99990	3.916	0.99995
3.105	0.9990	3.320	0.9995	3.759	0.99991	3.976	0.99996
3.138	0.9991	3.389	0.9996	3.791	0.99992	4.055	0.99997
3.174	0.9992	3.480	0.9997	3.826	0.99993	4.173	0.99998
3.215	0.9993	3.615	0.9998	3.867	0.99994	4.417	0.99999
	0.9994		0.9999		0.99995		1.00000

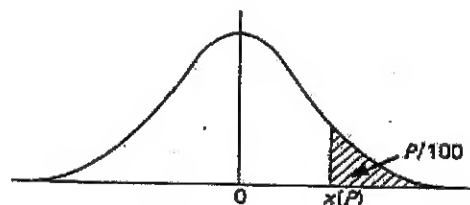
When $z > 3.3$ the formula $1 - \Phi(z) \approx \frac{e^{-z^2}}{z\sqrt{2\pi}} \left[1 - \frac{1}{z^2} + \frac{3}{z^4} - \frac{15}{z^6} + \frac{105}{z^8} \right]$ is very accurate, with relative error less than $945/z^{10}$.

TABLE 5. PERCENTAGE POINTS OF THE NORMAL DISTRIBUTION

This table gives percentage points $z(P)$ defined by the equation

$$\frac{P}{100} = \frac{1}{\sqrt{2\pi}} \int_{z(P)}^{\infty} e^{-t^2/2} dt.$$

If X is a variable, normally distributed with zero mean and unit variance, $P/100$ is the probability that $X \geq z(P)$. The lower P per cent points are given by symmetry as $-z(P)$, and the probability that $|X| \geq z(P)$ is $2P/100$.



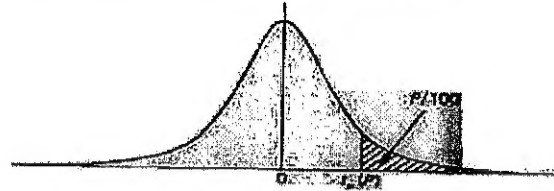
P	$z(P)$	P	$z(P)$	P	$z(P)$	P	$z(P)$	P	$z(P)$	P	$z(P)$
50	0.0000	5.0	1.6449	3.0	1.8808	2.0	2.0537	1.0	2.3263	0.10	3.0902
45	0.1257	4.8	1.6646	2.9	1.8957	1.9	2.0749	0.9	2.3656	0.09	3.1214
40	0.2533	4.6	1.6849	2.8	1.9110	1.8	2.0969	0.8	2.4089	0.08	3.1559
35	0.3853	4.4	1.7060	2.7	1.9268	1.7	2.1201	0.7	2.4573	0.07	3.1947
30	0.5244	4.2	1.7279	2.6	1.9431	1.6	2.1444	0.6	2.5121	0.06	3.2389
25	0.6745	4.0	1.7507	2.5	1.9600	1.5	2.1701	0.5	2.5758	0.05	3.2905
20	0.8416	3.8	1.7744	2.4	1.9774	1.4	2.1973	0.4	2.6521	0.04	3.7190
15	1.0364	3.6	1.7991	2.3	1.9954	1.3	2.2262	0.3	2.7478	0.005	3.8906
10	1.2816	3.4	1.8250	2.2	2.0141	1.2	2.2571	0.2	2.8782	0.001	4.2649
5	1.6449	3.2	1.8522	2.1	2.0335	1.1	2.2904	0.1	3.0902	0.0005	4.4172

TABLE 10. PERCENTAGE POINTS OF THE *t*-DISTRIBUTION

This table gives percentage points $t_p(P)$ defined by the equation

$$\frac{P}{100} = \frac{1}{\sqrt{\pi}} \frac{\Gamma(\frac{1}{2}(\nu+1))}{\Gamma(\frac{1}{2}\nu)} \int_{t_p(P)}^{\infty} \frac{dt}{(1+t^2/\nu)^{(\nu+1)/2}}$$

Let X_1 and X_2 be independent random variables having a normal distribution with zero mean and unit variance and a χ^2 -distribution with ν degrees of freedom respectively; then $t = X_1/\sqrt{X_2/\nu}$ has Student's t -distribution with ν degrees of freedom, and the probability that $t \geq t_p(P)$ is $P/100$. The lower percentage points are given by symmetry as $-t_p(P)$, and the probability that $|t| \geq t_p(P)$ is $2P/100$.



The limiting distribution of t as ν tends to infinity is the normal distribution with zero mean and unit variance. When ν is large interpolation in ν should be harmonic.

P	40	30	25	20	15	10	5	2.5	1	0.5	0.1	0.05
$\nu = 1$	0.3249	0.7265	1.0000	1.3764	1.963	3.078	6.314	12.71	31.82	63.66	318.3	636.6
2	0.2887	0.6172	0.8165	1.0607	1.386	1.886	2.920	4.303	6.965	9.925	22.32	31.60
3	0.2767	0.5844	0.7649	0.9785	1.250	1.638	2.353	3.182	4.541	5.841	10.21	12.92
4	0.2707	0.5686	0.7407	0.9410	1.190	1.533	2.132	2.776	3.747	4.604	7.173	8.610
5	0.2672	0.5594	0.7267	0.9195	1.156	1.476	2.015	2.571	3.365	4.032	5.893	6.859
6	0.2648	0.5534	0.7176	0.9057	1.134	1.440	1.943	2.447	3.143	3.707	5.203	5.959
7	0.2632	0.5491	0.7111	0.8960	1.119	1.415	1.895	2.365	2.998	3.499	4.781	5.408
8	0.2619	0.5459	0.7064	0.8889	1.108	1.397	1.860	2.306	2.896	3.355	4.501	5.041
9	0.2610	0.5435	0.7027	0.8834	1.100	1.383	1.833	2.262	2.821	3.250	4.297	4.781
10	0.2602	0.5415	0.6998	0.8791	1.093	1.372	1.812	2.228	2.764	3.169	4.144	4.587
11	0.2596	0.5399	0.6974	0.8755	1.088	1.363	1.796	2.201	2.718	3.106	4.023	4.437
12	0.2590	0.5386	0.6955	0.8726	1.083	1.356	1.782	2.179	2.681	3.055	3.930	4.318
13	0.2586	0.5375	0.6938	0.8702	1.079	1.350	1.771	2.160	2.650	3.012	3.853	4.222
14	0.2582	0.5366	0.6924	0.8681	1.076	1.345	1.761	2.145	2.624	2.977	3.781	4.140
15	0.2579	0.5357	0.6912	0.8662	1.074	1.341	1.753	2.131	2.602	2.947	3.733	4.073
16	0.2576	0.5350	0.6901	0.8647	1.071	1.337	1.746	2.120	2.583	2.921	3.686	4.015
17	0.2573	0.5344	0.6892	0.8633	1.069	1.333	1.740	2.110	2.567	2.898	3.646	3.965
18	0.2571	0.5338	0.6884	0.8620	1.067	1.330	1.734	2.101	2.552	2.878	3.610	3.922
19	0.2569	0.5333	0.6876	0.8610	1.066	1.328	1.729	2.093	2.539	2.861	3.575	3.883
20	0.2567	0.5329	0.6870	0.8600	1.064	1.325	1.725	2.086	2.528	2.845	3.552	3.850
21	0.2566	0.5325	0.6864	0.8591	1.063	1.323	1.721	2.080	2.518	2.831	3.527	3.819
22	0.2564	0.5321	0.6858	0.8583	1.061	1.321	1.717	2.074	2.508	2.819	3.505	3.792
23	0.2563	0.5317	0.6853	0.8575	1.060	1.319	1.714	2.069	2.500	2.807	3.485	3.768
24	0.2562	0.5314	0.6848	0.8569	1.059	1.318	1.711	2.064	2.492	2.797	3.467	3.745
25	0.2561	0.5312	0.6844	0.8562	1.058	1.316	1.708	2.060	2.485	2.787	3.450	3.725
26	0.2560	0.5309	0.6840	0.8557	1.058	1.315	1.706	2.056	2.479	2.779	3.435	3.707
27	0.2559	0.5306	0.6837	0.8551	1.057	1.314	1.703	2.052	2.473	2.771	3.421	3.690
28	0.2558	0.5304	0.6834	0.8546	1.056	1.313	1.701	2.048	2.467	2.763	3.408	3.674
29	0.2557	0.5302	0.6830	0.8542	1.055	1.311	1.699	2.045	2.462	2.756	3.396	3.659
30	0.2556	0.5300	0.6828	0.8538	1.055	1.310	1.697	2.042	2.457	2.750	3.385	3.646
32	0.2555	0.5297	0.6822	0.8530	1.054	1.309	1.694	2.037	2.449	2.738	3.365	3.622
34	0.2553	0.5294	0.6818	0.8523	1.052	1.307	1.691	2.032	2.441	2.728	3.348	3.601
36	0.2552	0.5291	0.6814	0.8517	1.052	1.306	1.688	2.028	2.434	2.719	3.333	3.582
38	0.2551	0.5288	0.6810	0.8512	1.051	1.304	1.686	2.024	2.429	2.712	3.319	3.566
40	0.2550	0.5286	0.6807	0.8507	1.050	1.303	1.684	2.021	2.423	2.704	3.307	3.551
50	0.2547	0.5278	0.6794	0.8489	1.047	1.299	1.676	2.009	2.403	2.678	3.261	3.496
60	0.2545	0.5272	0.6786	0.8477	1.045	1.296	1.671	2.000	2.390	2.660	3.232	3.460
120	0.2539	0.5258	0.6765	0.8446	1.041	1.289	1.658	1.980	2.358	2.617	3.160	3.373
∞	0.2533	0.5244	0.6745	0.8416	1.036	1.282	1.645	1.960	2.326	2.576	3.090	3.291